Scanning High Resolution Interferometer Sounder (S-HIS)

Hank Revercomb, Joe Taylor, Fred Best, Dave Tobin, Jon Gero, Bob Knuteson, Ray Garcia, Nick Ciganovich, Paolo Antonelli, Dan DeSlover, Bill Smith, Elisabeth Weisz, Elise Garms

University of Wisconsin-Madison

Space Science and Engineering Center

THE UNIVERSITY of WISCONSIN MADISON

HS3 Science and Deployment Preparation Meeting

Wallops Flight Facility, VA

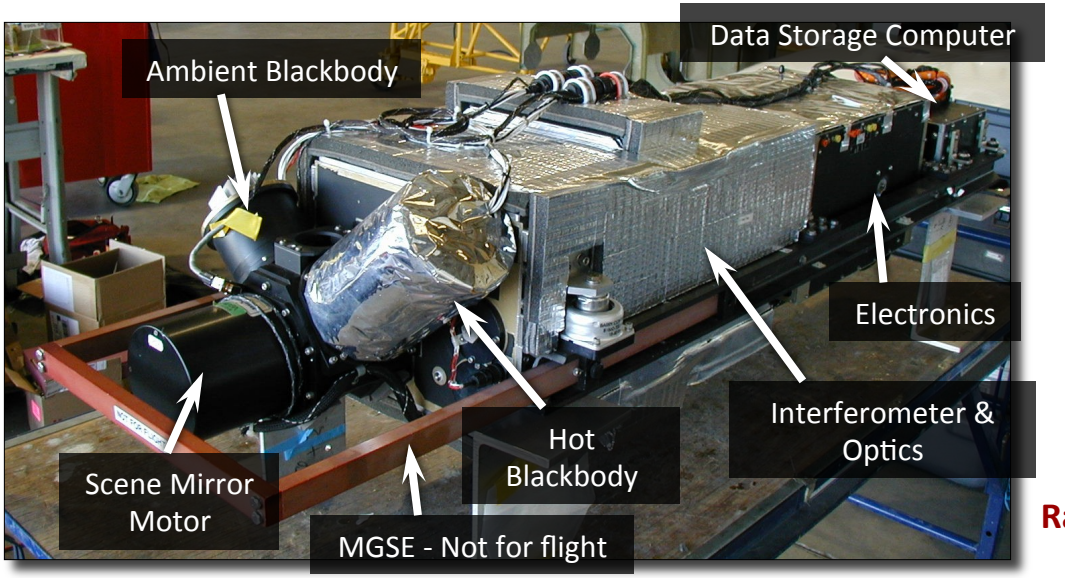
7 – 8 May 2012

SSEC

Outline

- Instrument overview
- Instrument status
  - Cooling strategy
  - Pre-mission calibration and calibration verification
- Data products and data rates
  - Real-time product considerations

Instrument Overview:

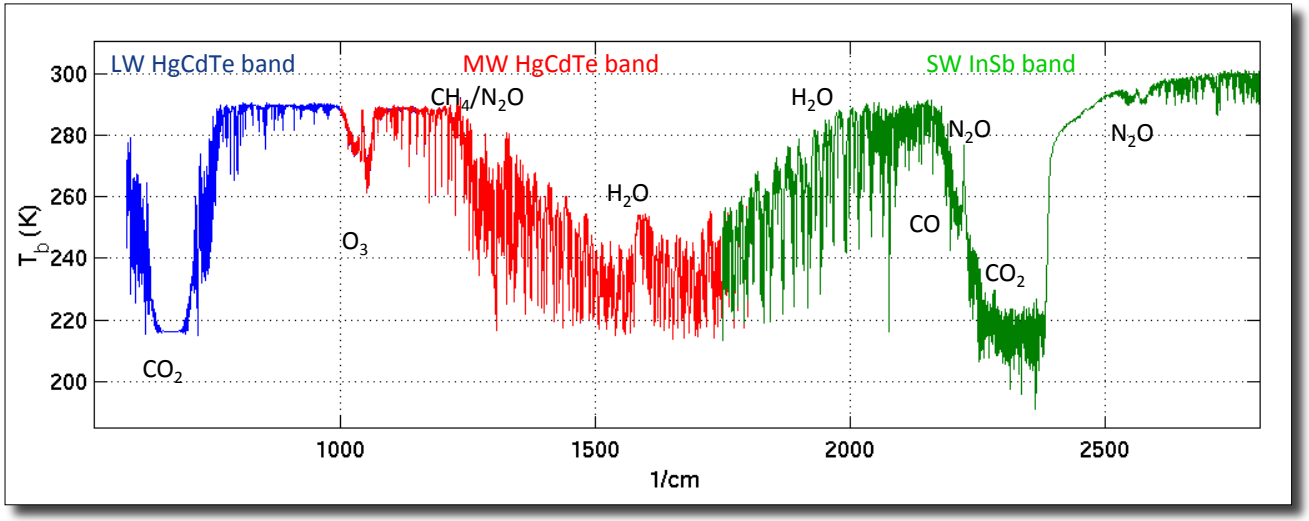


Spectral Coverage: 580 - 3000 cm^{-1}
LW: 580 - 1200 cm^{-1}
MW: 1000 - 1820 cm^{-1}
SW: 1750 - 3000 cm^{-1}
Spectral Resolution: 0.5 cm^{-1}

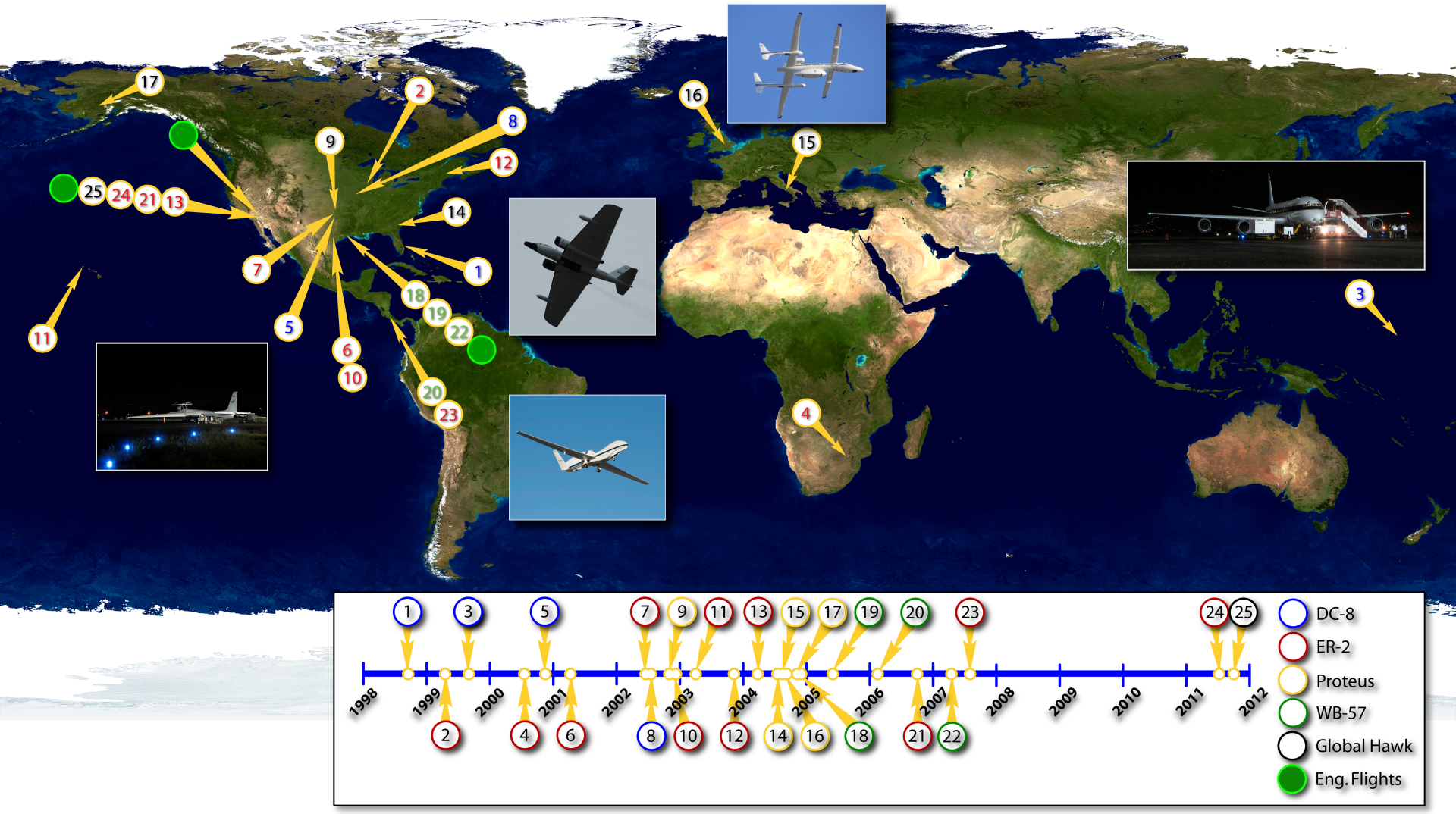
Interferometer Type: DA plane mirror (mod. Bomem DA-5)
IFOV: 100 mrad (2 km @ 20 km)
Field Mirror Scan: Programmable
RMS Noise (per spot): < 0.25K at 260K
Radiometric Calibration: < 0.5K; absolute
< 0.2K; reproducibility

Applications

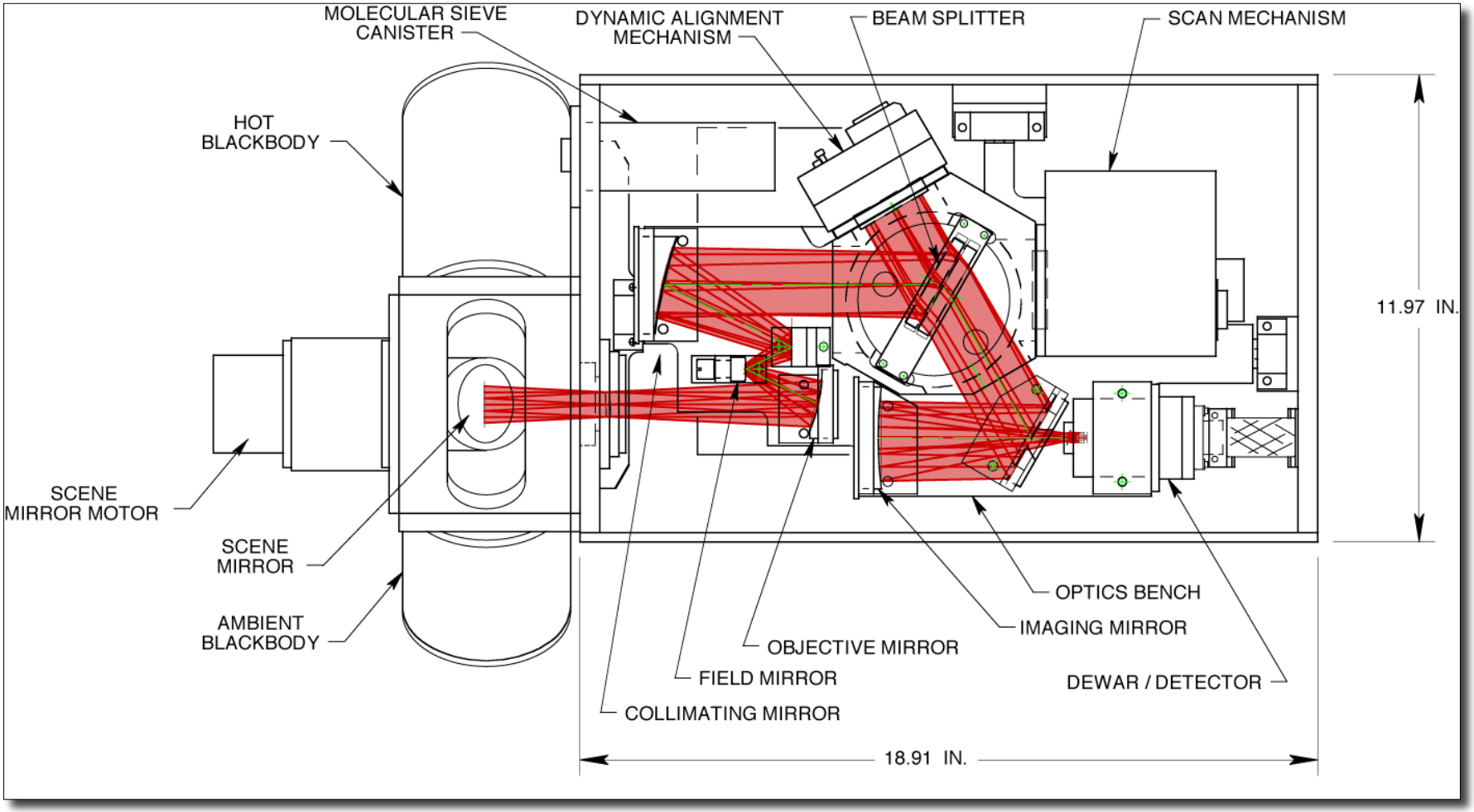
- Radiances for Radiative Transfer
- Temp & Water Vapor Retrievals
- Cloud Radiative Prop.
- Surface Emissivity & T
- Trace Gas Retrievals
- Calibration Validation



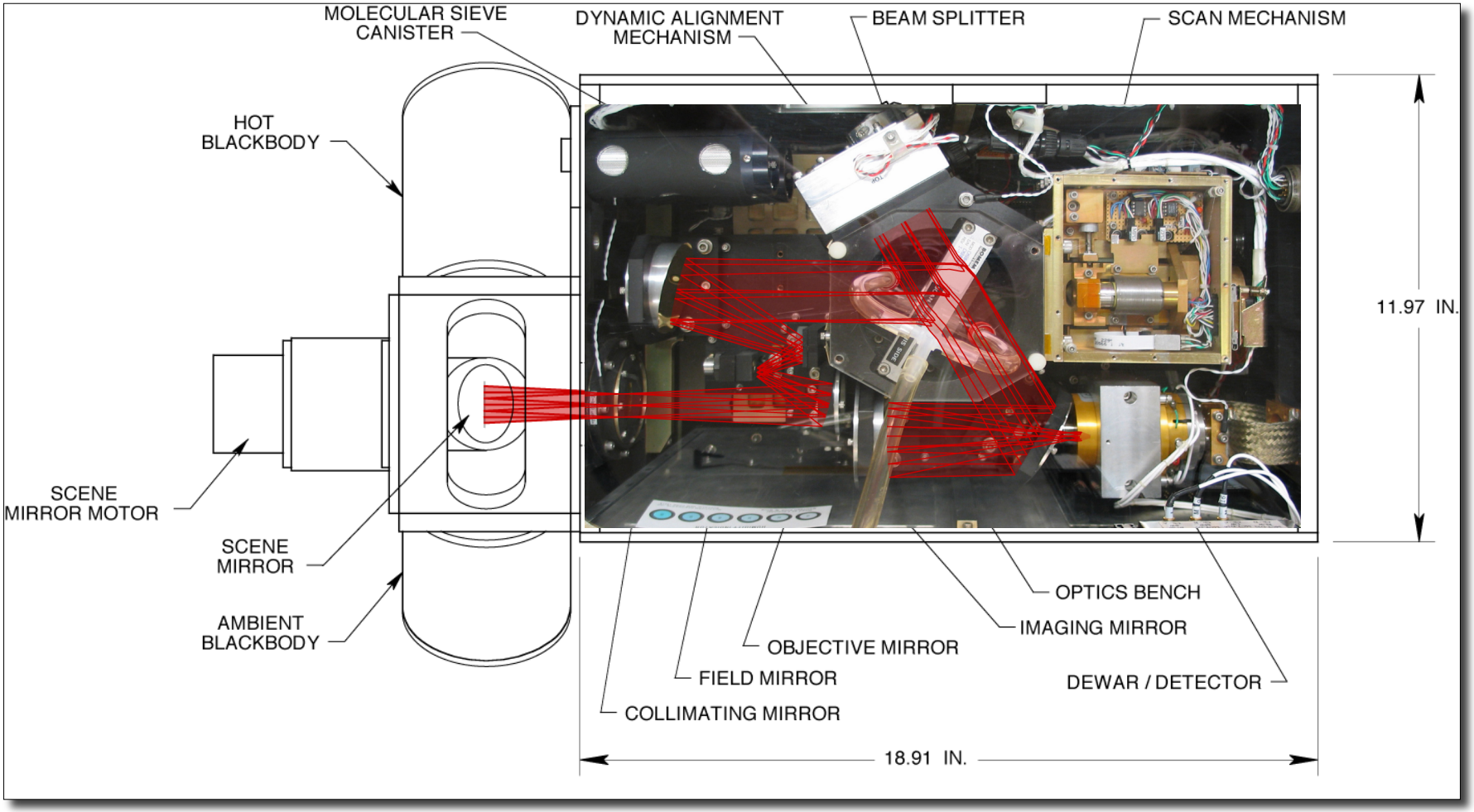
Instrument Overview



Instrument Overview: Interferometer



Instrument Overview: Interferometer



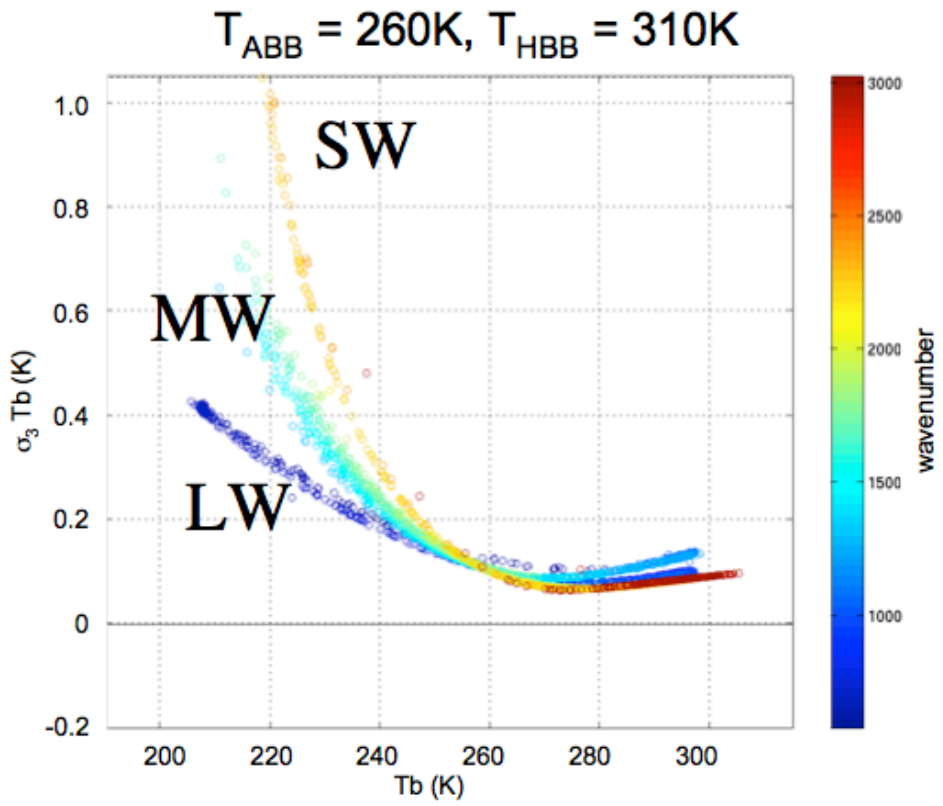
Instrument Overview
Radiometric Calibration

- The blackbody reference sources for the S-HIS are high emissivity cavities (normal emissivity ≈ 0.999) carefully designed, fabricated, and characterized at the UW-SSEC
- NIST traceability is a priority
- For TB ≥ 220K the resulting absolute radiometric accuracy is better than 0.5 K (3-sigma) and the reproducibility is better than 0.2 K
- These are conservative estimates of the uncertainty, with the absolute accuracy representing a not to exceed value.
- An RSS of the error contributors indicates expected uncertainties that are about half of these values over much of the spectrum, and ground tests with a third blackbody confirm this tighter expectation.

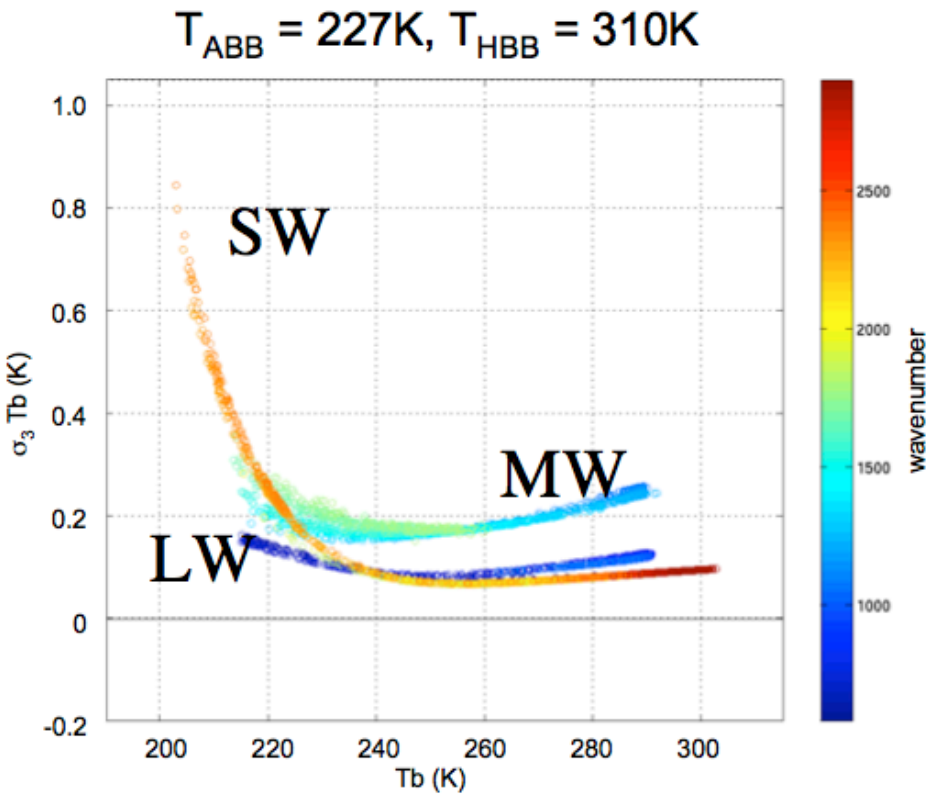
Instrument Overview: Radiometric Calibration

S-HIS Radiometric Calibration Budgets

****3-sigma Uncertainties**

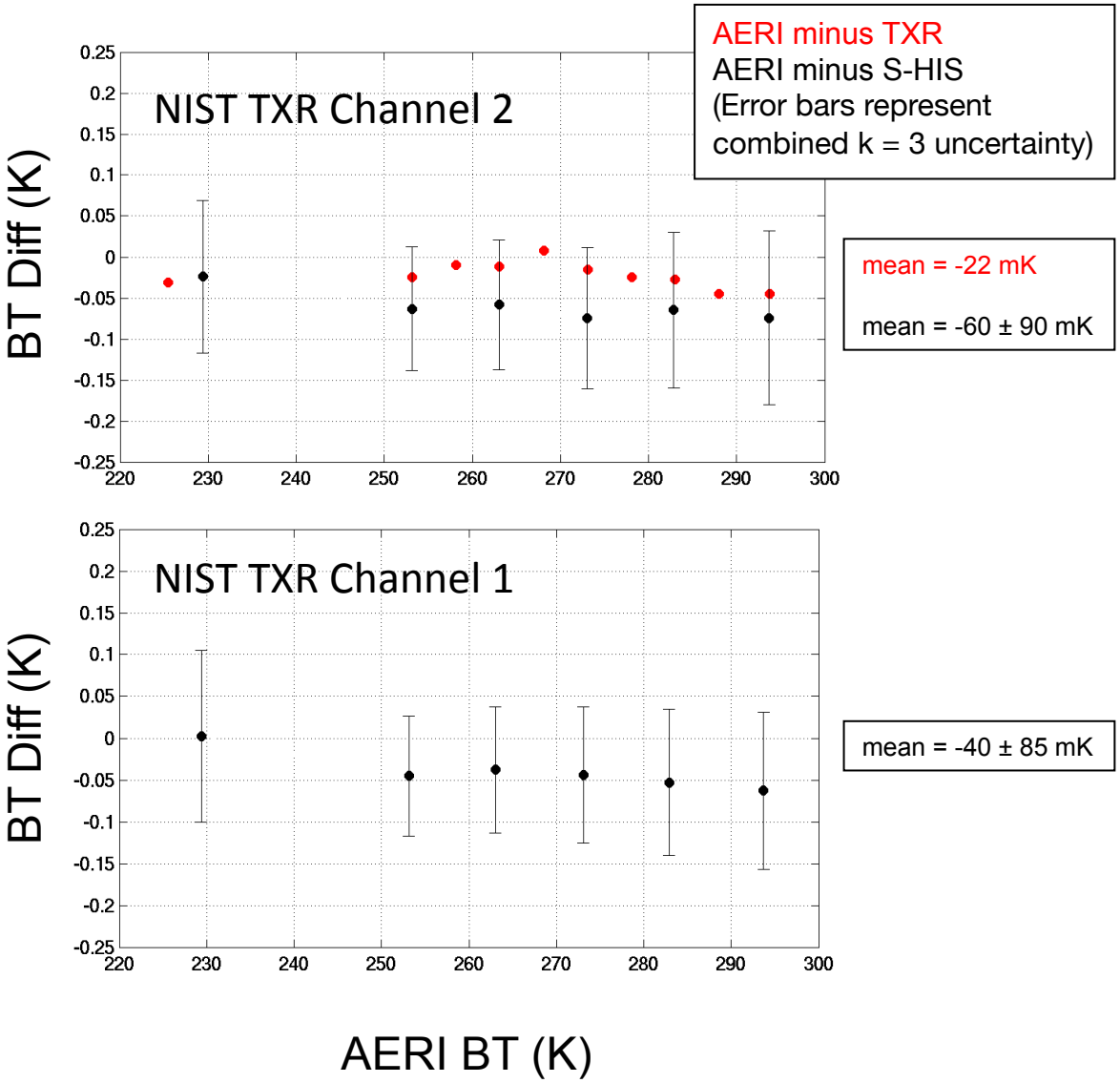


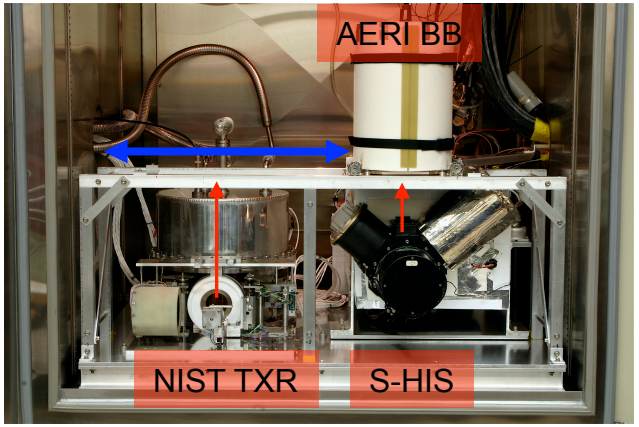
21 November 2002
on ER2

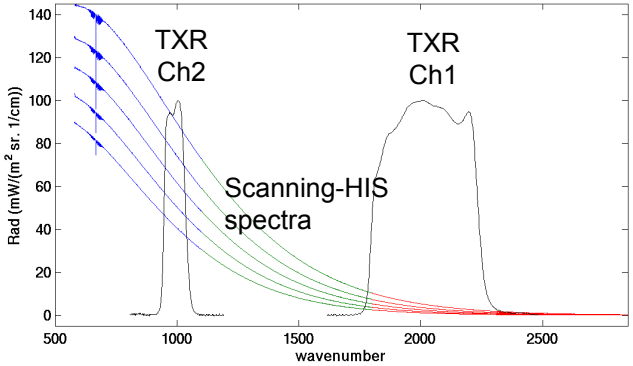


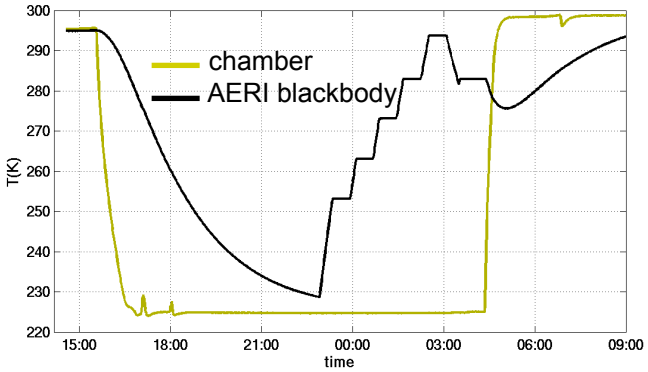
16 November 2002
on Proteus

Instrument Overview: Radiometric Calibration Verification, Comparison with NIST TXR



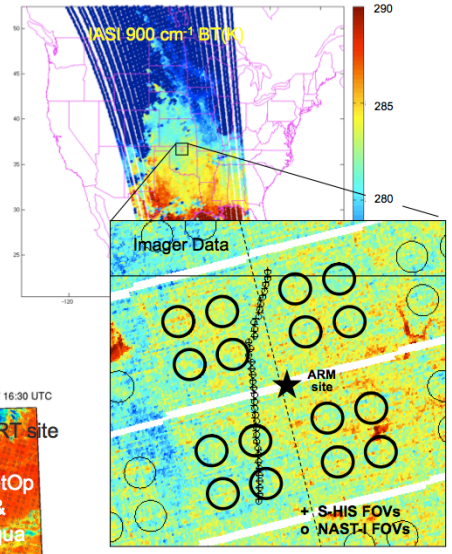


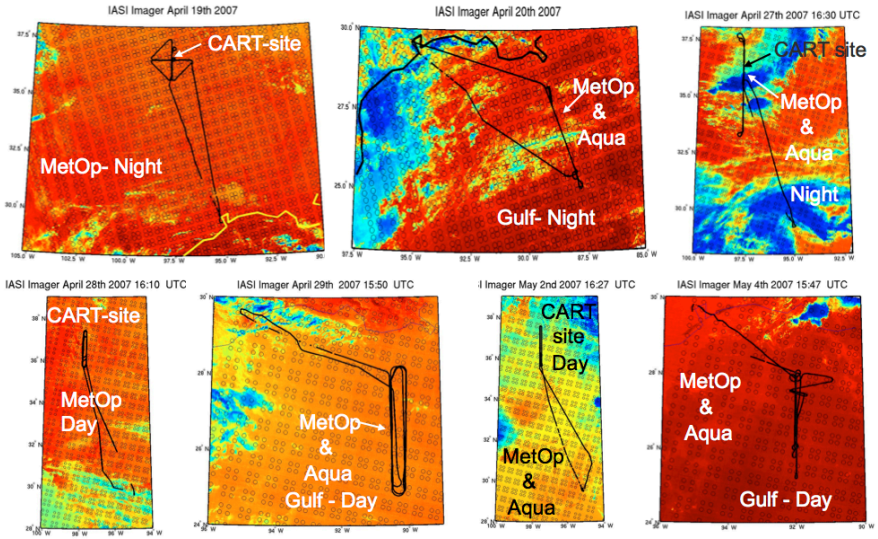


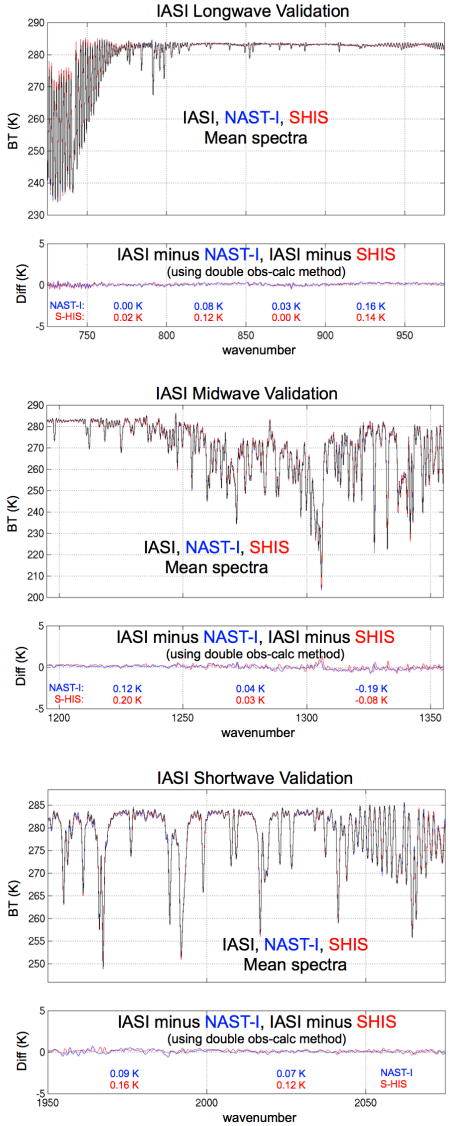


Instrument Overview: Calibration Validation Example

Established high absolute accuracy and ties to NIST standards make S-HIS a valuable calibration validation tool for IASI, AIRS, CrIS, MODIS, …







Instrument Status: Calibration and Calibration Verification

- Calibration and Calibration Verification
  - Blackbody Reference Calibration in progress.
    - Electronics calibration is complete,
    - Thermistor calibration in process.
  - End to end system calibration verification will be completed after blackbody calibration is complete, prior to deployment, and again post-deployment

Calibration Configuration: Calibration from -60° to +60

Wavelength LFI-3751
Temperature Controller

Thermal Chamber

ABB

HBB

Cavity Heater Power

Feedback Thermisor

Thermistors (3)

Thermistors (3)

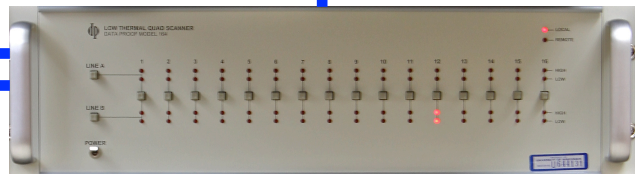
Feedback Thermisor

Cavity Heater Power

Wavelength LFI-3751
Temperature Controller

Thermometrics SP-60
Temperature Probes (2)

Fluke 8508A
Reference Multimeter



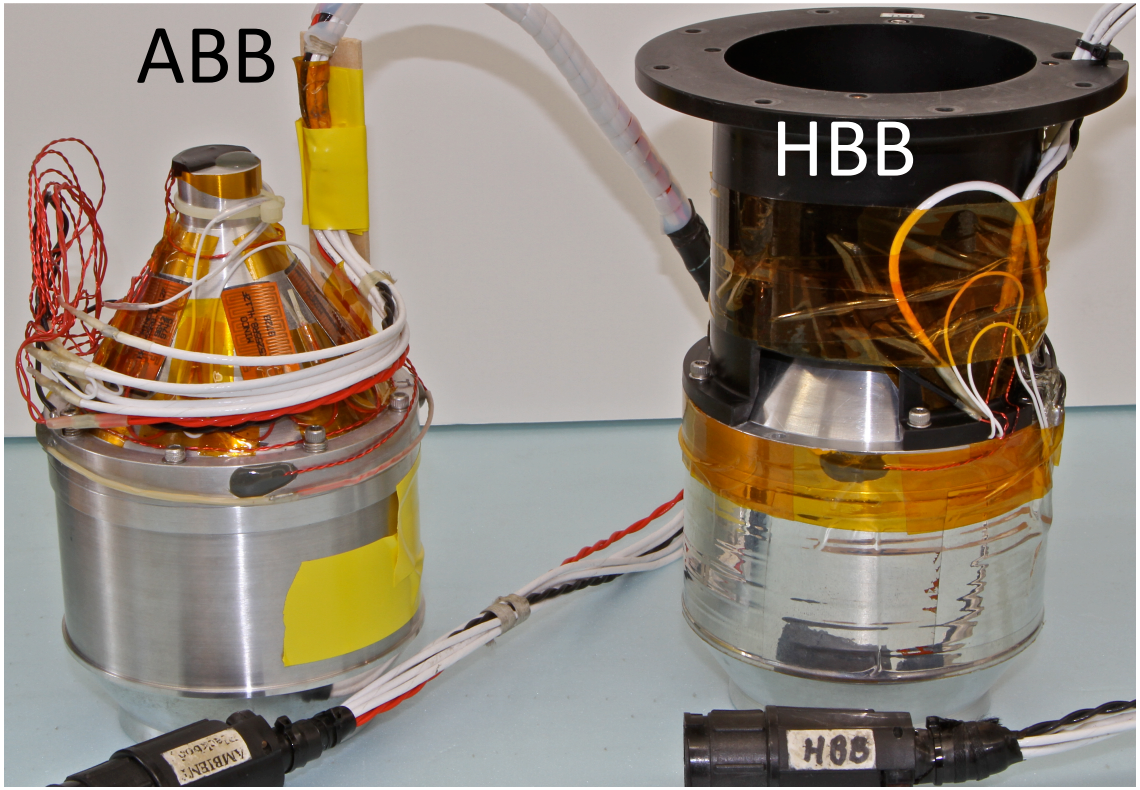
Data Proof Model 164
Low Thermal Quad Scanner

Dell R5400
Precision Workstation

Tprobe &
Rthermistor

Hart 2563 Thermistor Module
With Readout Electronics
Calibrated at Hart with
Temperature Probes to 5mK (k=3)

Scanning HIS Blackbodies



- Only Cone used for flight configuration
- Minco Heaters shown are Descent Heaters
- Aluminum Barrel added for calibration only
- Normally the structural support (tube) to the enclosure is aluminum for better coupling, for calibration this changed to Noryl.

- Flight configuration is shown above
- Flight configuration uses Noryl enclosure
- Normal AERI-Style circumferential wire wrap heater used around barrel

ABB and HBB With Calibration Plugs Installed

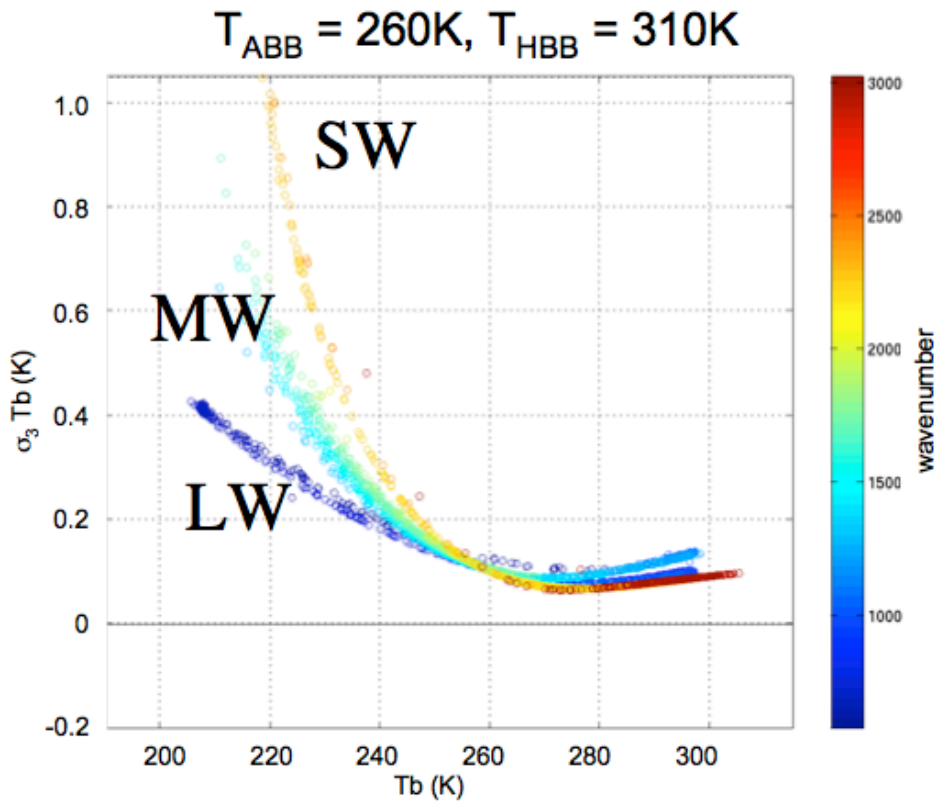
Instrument Status: Instrument Temperature

- Zone 25 on GH represents warmest airborne environment for S-HIS to date.
- This presents issues for calibration accuracy and instrument health
- Working with GH group on cooling solution for S-HIS Ambient Blackbody, cooler compressor/expander, and warmest electronic components
- Thermal concept delivered to Dave Fratello. Design is based on design option sent by Global Hawk engineers.
- The concept uses thermal straps to couple discrete hot spots in the instrument to a plumbed-in air stream

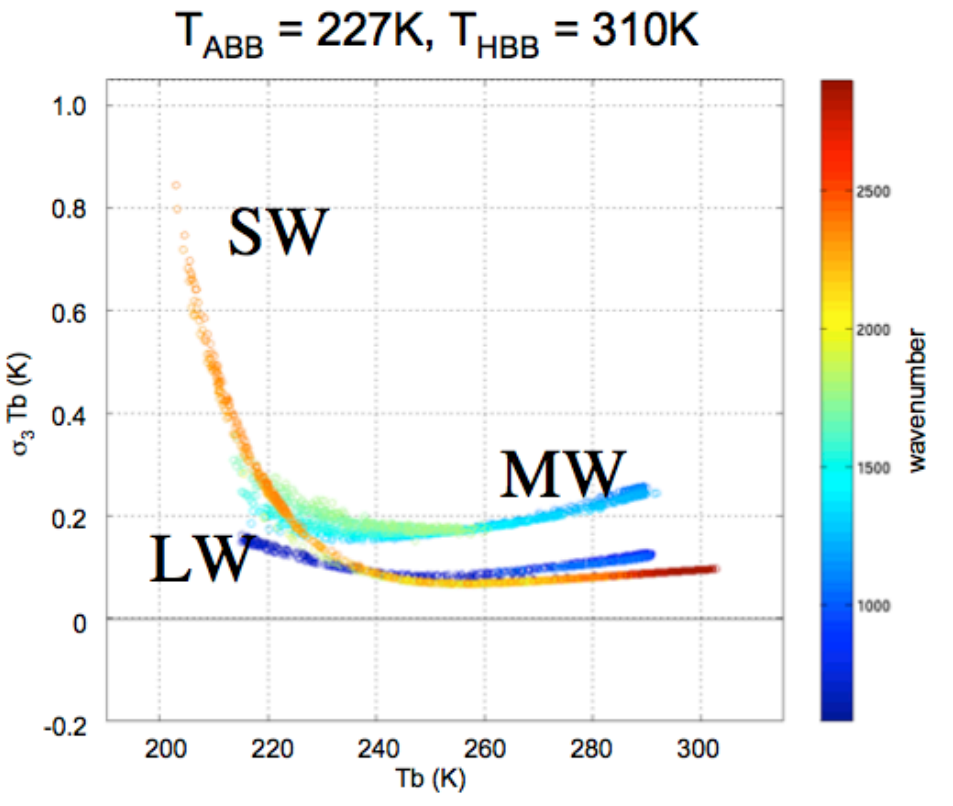
Instrument Status: Instrument Temperature ABB Temperature and Calibration Uncertainty

S-HIS Radiometric Calibration Budgets

****3-sigma Uncertainties**



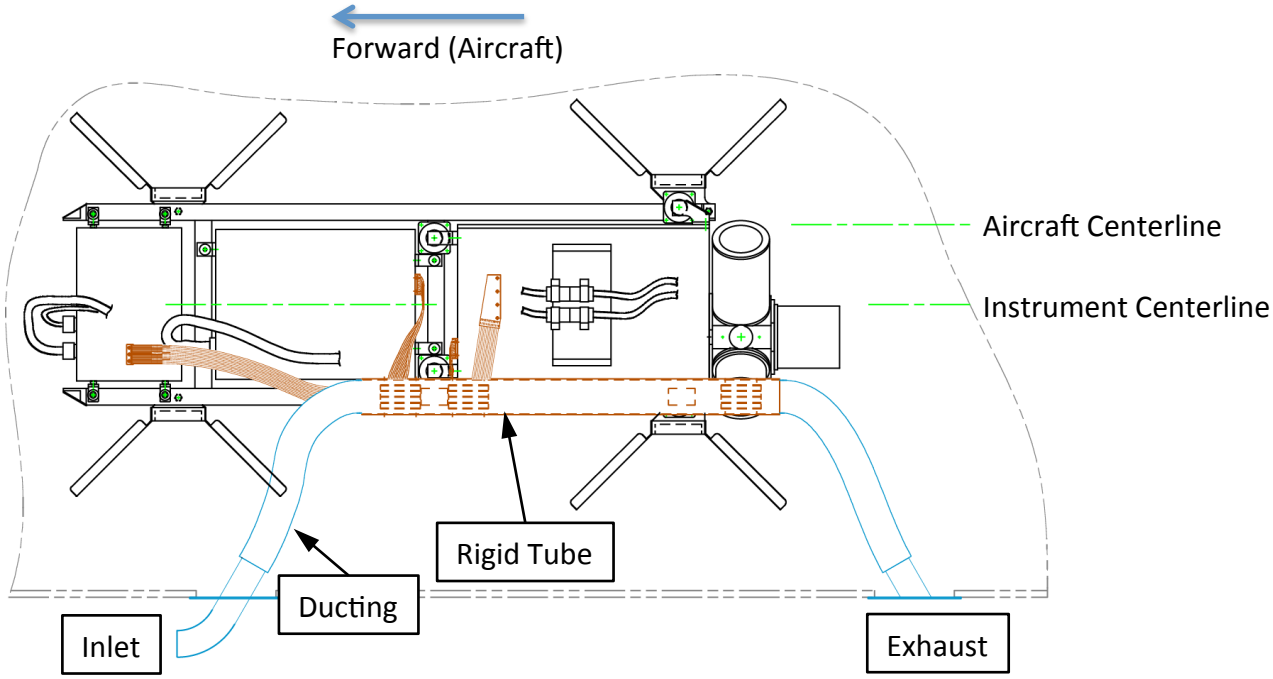
21 November 2002
on ER2



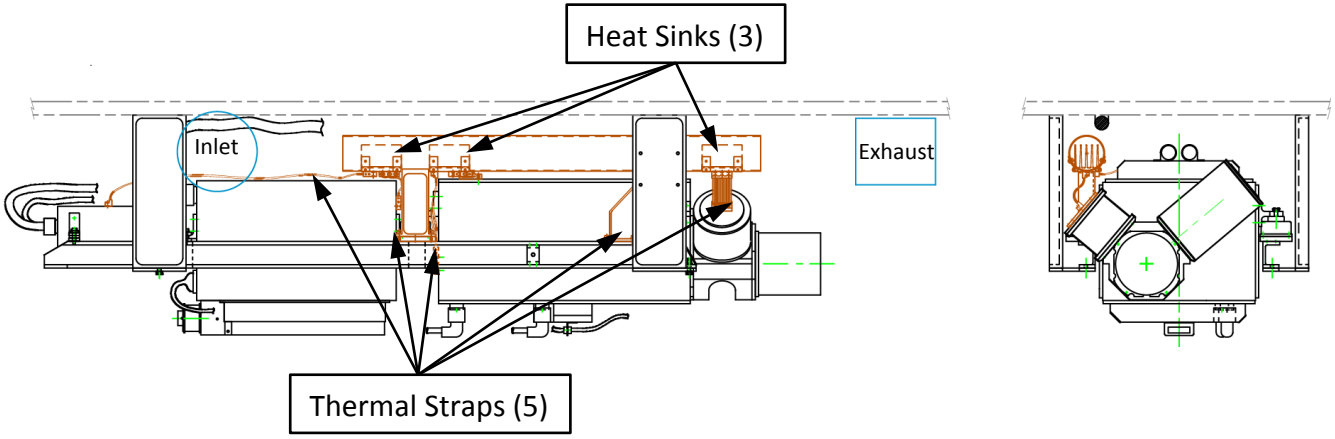
16 November 2002
on Proteus

Instrument Status: Instrument Temperature

Instrument Status: Instrument Temperature



- NASA provided ducting items shown in blue
- New S-HIS provided parts shown in brown
- S-HIS internal thermal straps not shown



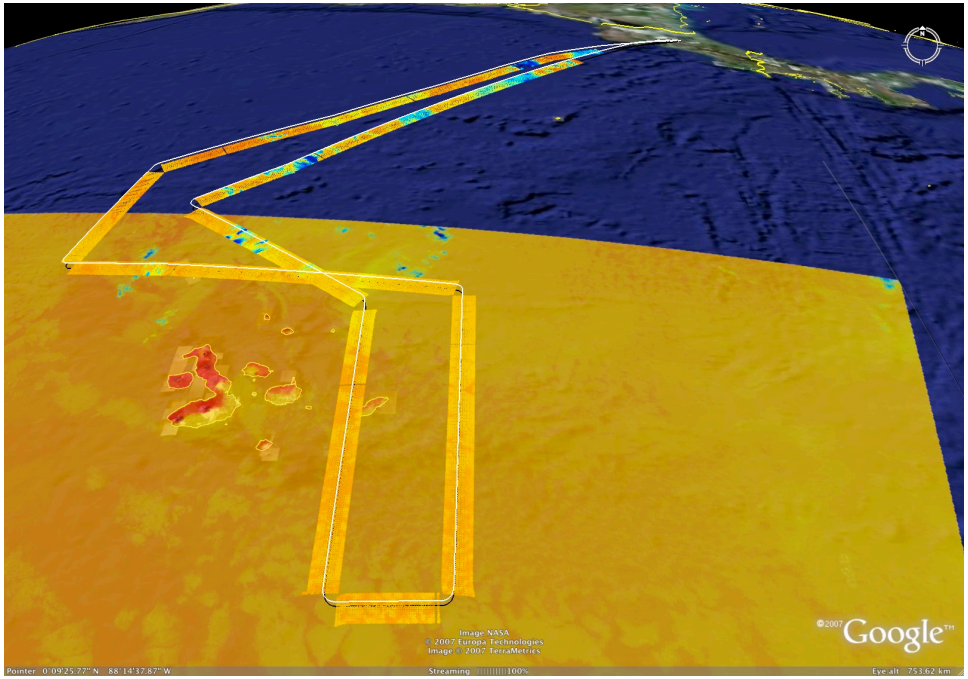
Data Products

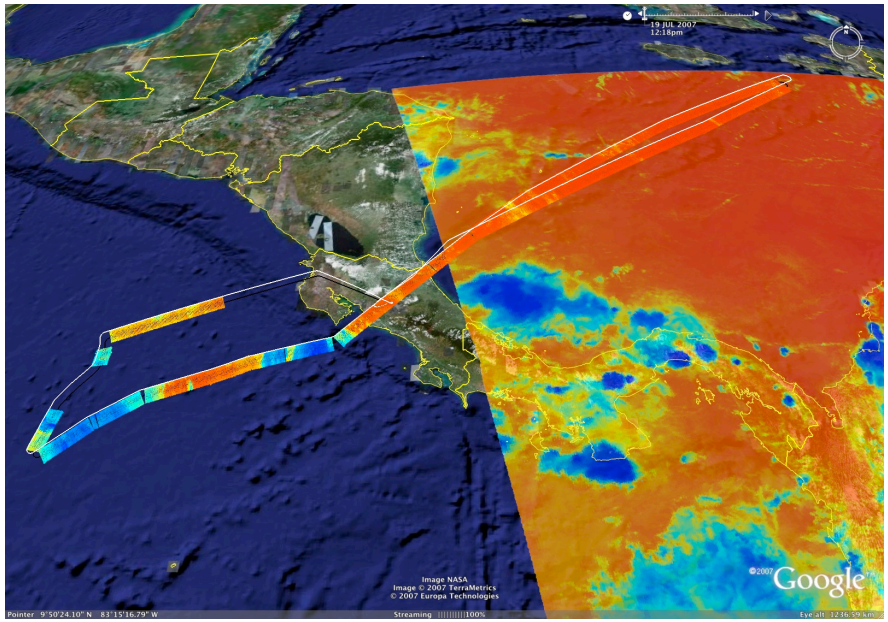
- Infrared spectrally resolved radiances (580 – 3000 cm^{-1}) with high absolute accuracy
  - Brightness Temperature maps
  - Temperature & Water Vapor Retrievals
  - Cloud Radiative Properties, Surface Temperature and Emissivity, Radiative Transfer, Trace Gas Retrievals, Calibration Validation, …

Data Products: example: BT Plots

Brightness temperature maps can be produced for any desired spectral region in the S-HIS coverage and exported to .kml/.kmz (900 cm^{-1} example shown below)

S-HIS data in Google Earth (07-08-06): The image shows the Terra MODIS band 31 image for 2007218.1645, with the S-HIS 900 cm-1 BT for straight and level segments, along with the flight profile and ground track

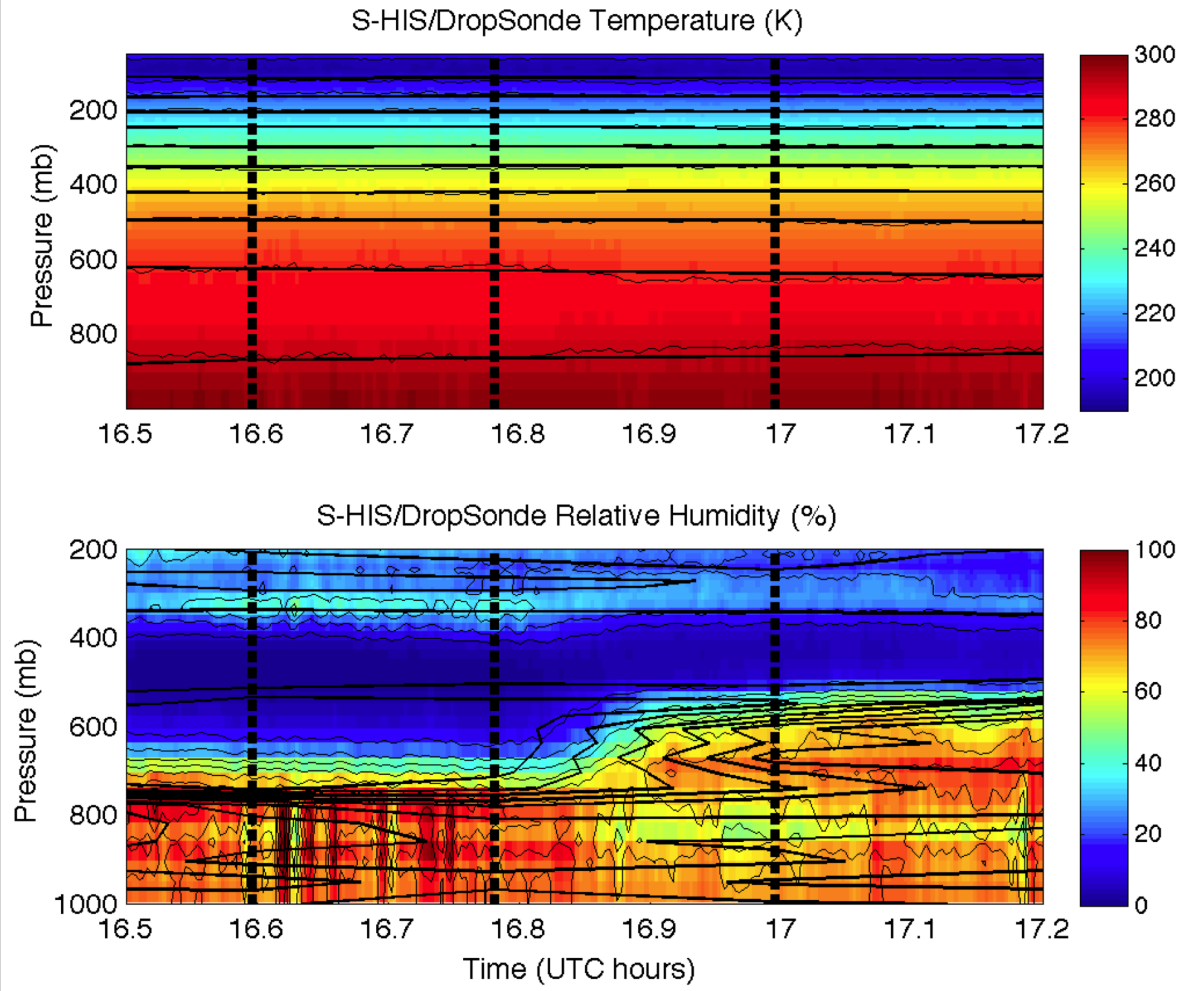


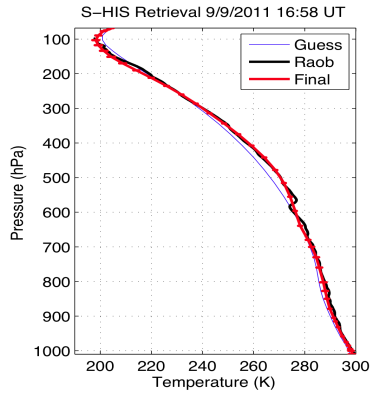


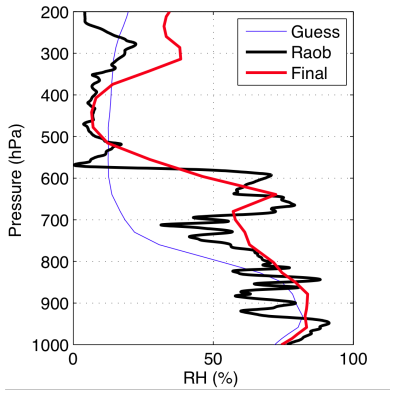
S-HIS data in Google Earth (07-07-19): The image shows the AQUA MODIS band 31 image for 2007200.1815, with the S-HIS 900 cm-1 BT for straight and level segments, along with the flight profile and ground track

Data Products:
Retrievals: UW Scanning-HIS T/WV Retrieval Example: 9/9/2011

Details in Knuteson Presentation Monday PM







Data Products and Data Rates: Total Data Volume (26 hour flight)

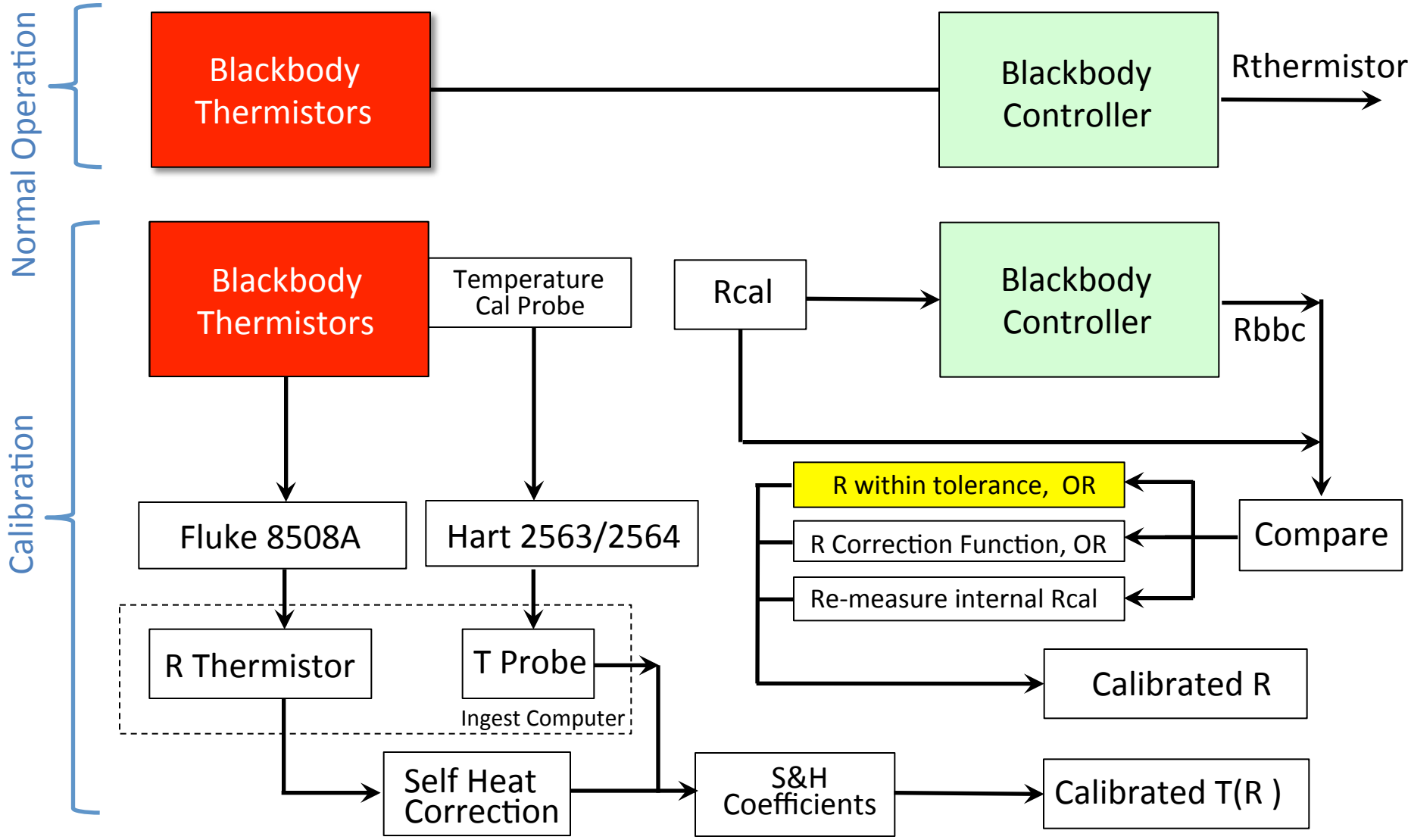
- Data Volume for a 26-hour flight
- RDR (raw):
  - 52 RSH packet-stream raw data files,
  - <= 200 Mbytes each = 10 Gbytes
- SDR (radiances):
  - Five 6-hour radiance NetCDF file sets
  - <= 1Gbyte per set = 5Gbytes
- EDR (retrievals):
  - Five 6-hour retrieval NetCDF/MAT file sets
  - <= 600 Mbytes per set = 3Gbytes
- Grand total = 18 Gbytes for a 26 hour flight

Data Products and Data Rates: Real Time Products

- Raw Data Rate: sustained average of 1Mbit/s
- Workable options for decimation are combinations of
  - sweep direction decimation
  - scene view decimation (i.e. nadir and cal views only)
  - packet filtering time decimation (full sets of scenes but only every few minutes)
  - spectral resolution reduction
- Significant development effort required for data rate decimation
  - estimate that for every factor of two we reduce from 1Mbit/s of bandwidth, we're likely to need 2-4 human-weeks of effort

Extra Slides

Calibration Philosophy



Calibration Configuration: Calibration from -60° to +60

Wavelength LFI-3751
Temperature Controller

Thermal Chamber

ABB

HBB

Cavity Heater Power

Feedback Thermisor

Thermistors (3)

Thermistors (3)

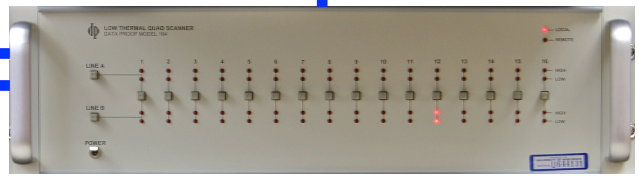
Feedback Thermisor

Cavity Heater Power

Wavelength LFI-3751
Temperature Controller

Thermometrics SP-60
Temperature Probes (2)

Fluke 8508A
Reference Multimeter



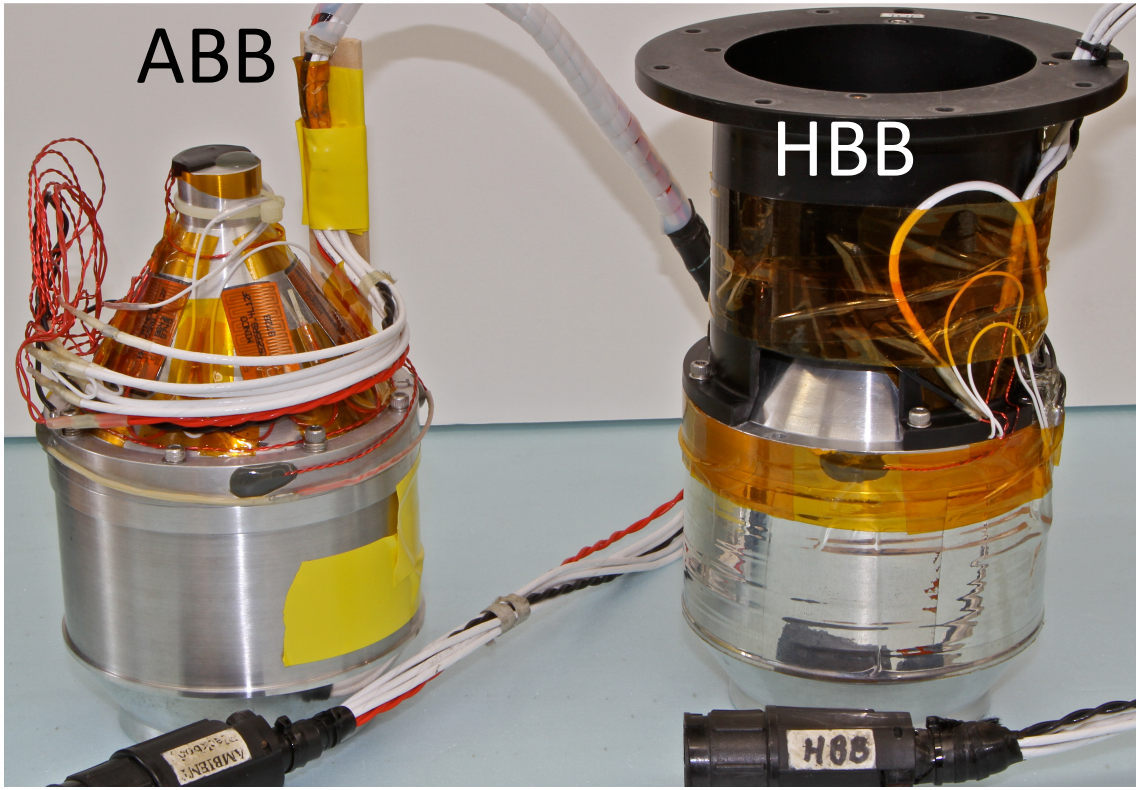
Data Proof Model 164
Low Thermal Quad Scanner

Dell R5400
Precision Workstation

Tprobe &
Rthermistor

Hart 2563 Thermistor Module
With Readout Electronics
Calibrated at Hart with
Temperature Probes to 5mK (k=3)

Scanning HIS Blackbodies



- Only Cone used for flight configuration
- Minco Heaters shown are Descent Heaters
- Aluminum Barrel added for calibration only
- Normally the structural support (tube) to the enclosure is aluminum for better coupling, for calibration this changed to Noryl.

- Flight configuration is shown above
- Flight configuration uses Noryl enclosure
- Normal AERI-Style circumferential wire wrap heater used around barrel

Instrument Overview

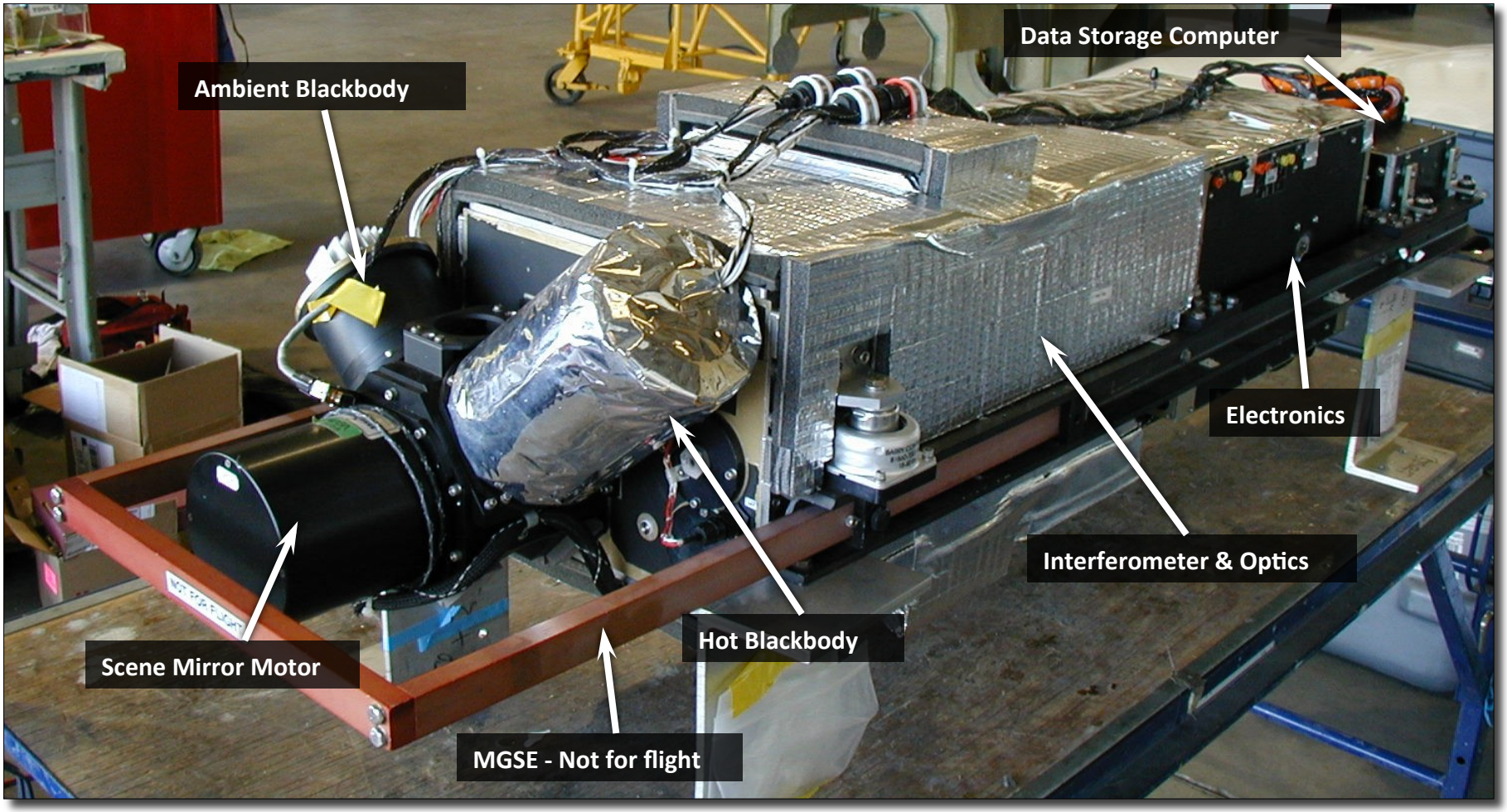
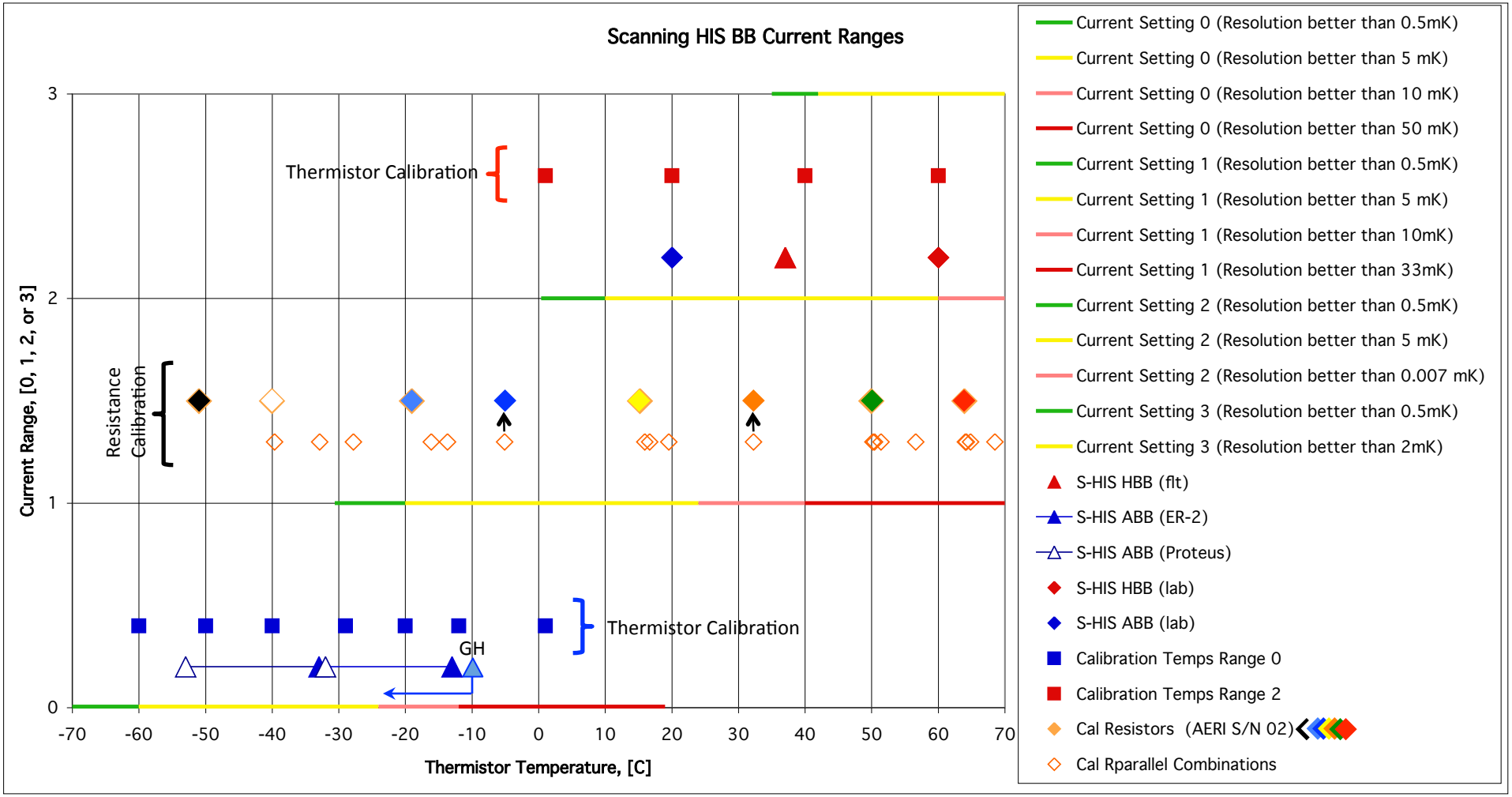


ABB and HBB With Calibration Plugs Installed

BB Operational and Calibration Temperatures



Instrument Overview: Radiometric Calibration

- Achieving high absolute accuracy has been a major objective of the S-HIS program at the UW-SSEC.
- Radiometric calibration of the S-HIS is accomplished with the same basic technique used in low resolution radiometry [Knuteson et al; 2004a, 2004b]. Periodic viewing of two high emissivity, uniform temperature blackbody references provides the responsivity and offset parameters needed to convert measured spectra to radiances.
- The ambient blackbody (ABB) is unheated and thermally coupled to the aircraft pod temperature while the HBB is maintained at a set temperature (typically 305 - 310K for flight).